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955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: August 26, 1971

to: Distribution

B71 08034

from: G. K. Chang

subject: Effect of Radiation on the Lunar Surface Ultraviolet Camera Film - Case 340

ABSTRACT

During the Apollo 16 mission, the Lunar Surface Ultraviolet Camera (LSUC) will be deployed on the lunar surface to photograph and record on film astronomical objects in the far ultraviolet spectrum (300-1550 Å). The NTB3 film used in the LSUC is extremely sensitive to charged particles. The Apollo 16 spacecraft will pass through the most intense region of the Van Allen radiation belt. Since the LSUC in the present stowage configuration (LM Quad III) has very little shielding against radiation, the film will be exposed to radiation of at least 10 Rad_{air} as the spacecraft passes through the Van Allen radiation belt. To test the effect of the trapped protons on the film, I recommend that the film along with the transport cassette be exposed to a dose of a few Rad_{air} of tens of Mev protons. If the film shows a positive effect, I suggest transport of the film cassette in the Command Module or strengthening of the radiation shield around the film transport cassette.

(NASA-CR-121546) EFFECT OF RADIATION ON THE LUNAR SURFACE ULTRAVIOLET CAMERA FILM, CASE 340 (Bellcomm, Inc.) 7 p

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MEMORANDUM FOR FILE

Introduction

The Lunar Surface Ultraviolet Camera (LSUC) (S201) will be transported in Quad III of the LM to the lunar surface where it will be deployed by the astronauts. During the lunar surface stay, the LSUC will photograph and record on film spectra of astronomical objects in the far ultraviolet spectrum (300-1550 Å). Near the end of the surface stay the film will be removed by the crew and returned for detailed analysis.

The LSUC is an electronographic camera which converts the far ultraviolet photons incident on the photocathode to electrons. The electrons are then accelerated and strike the nuclear track emulsion film. Since the emulsion is also sensitive to energetic protons (E > few Mev) and electrons (E > few Kev), passage through the earth's radiation belt (which contains large fluxes of protons and electrons in this energy range) could result in fogging of the film unless it is adequately shielded. Since a significant portion of the objectives of the experiment is to photograph faint objects, an increase of fogging density resulting from film exposure to a heavy radiation dose (a few Rad_{air}) may seriously compromise these results.

The shielding effectiveness of the LSUC stowage area on the translunar coast (TLC) phase of the Apollo 16 mission is investigated and recommendations made for minimizing the fogging due to the radiation in the Van Allen belt.

Radiation Exposure of the Apollo 16 Spacecraft

The Apollo 16 mission is scheduled for March 17, 1972 and the landing site is Descartes. For this mission the spacecraft trajectory will pass through the center of the intense Van Allen radiation belt (see attached figure). Using the trajectory for the (prime) Apollo 16 mission, the integrated proton flux for energy greater than 34 Mev alone is computed with the AP3 model of the Trapped Radiation Environment to be about 8×10^6 protons/cm^2 (Reference 1). This corresponds to a radiation dose of 1 to 2 Rad_{air}.

For a similar trajectory, the radiation doses for the Apollo 14 mission were computed, taking into account the electron flux above 0.5 Mev and the proton flux above 20 Mev (Reference 2). With the present configuration, the film could be exposed on such a trajectory to doses of at least 10 Rad_{air}.

Shielding

To effectively reduce the radiation exposure during the Apollo 16 TLC to a film fogging density increase of less than 0.1, shielding equivalent to 1.5 g/cm^2 aluminum is required.

The LSUC, including the film transport cassette, will be stowed in the LM Quad III on the way to the moon. The only shielding against radiation at the stowage area is the thermal blanket wrapped around the LM. The effective shielding of the thermal blanket at the Quad III area (Reference 3) is less than .05 gm/cm^2. The film transport cassette casing is 1/8 inch magnesium which corresponds to a shielding thickness of .5 g/cm^2. The total shielding effectiveness of the thermal blanket and the film cassette is only about 35% of that required to reduce the fogging to an acceptable level.

Prior to transposition and docking, the LM is enclosed in the Spacecraft LM Adapter (SLA). The SLA panels are an aluminum honeycomb structure which consists of an outer sheet 30 mil thick, 1.7 inch thick honeycomb cores and an inner sheet 30 mil thick which weighs about 3 lbs/cu. ft. (.23 g/cm^3). The SLA panels will provide some shielding against the radiation, but they will be ejected at an altitude of 2800 nm (based on Apollo 15 timeline) which is before the CSM/LM enters the most intense region of the Van Allen radiation belt. Consequently, the shielding surrounding the film during CSM/LM passage through the center of the Van Allen belt is no better than 35% of that required.

Film Fogging Due to Proton Radiation

The LSUC uses Kodak NTB3 type of film. The NTB3 is advertised as an extremely sensitive film which will record all charged particles with energies above a few Kev. However, quantitative information on the effect of its exposure to energetic protons is not available. Other similar types of film studied indicate that 1 to 2 Rad_{air} exposure to 50 Mev protons will result in a fogging density increase of 0.2 (Reference 4). On the Apollo 16 (prime) mission, the LM Quad III area would receive a dose of at least 2 Rad_{air}, and possibly more than 10 Rad_{air} as the spacecraft passes through the Van Allen radiation belt. A study on 3 Kodak nuclear track films exposed to a similar radiation environment (Reference 5) showed a fogging density increase of .861 for SO 166 film (Kodak High-Speed Panchromatic Film), of .536 for Kodak No-Screen Medical X-Ray Film and of .114 for Kodak Plus-X Aerial Film. Since NTB3 is a fast film, according to the LSUC PI its exposure to 5 Rad_{air} of protons is likely to have serious effects on the LSUC experiment.

Conclusion and Recommendation

Based on the available information, the film to be used in the LSUC experiment will be fogged due to radiation as the spacecraft passes through the Van Allen radiation belt. Adequate radiation protection is not provided in the LSUC stowage area (LM Quad III) nor by the film cassette. To assure that the trapped energetic protons in the radiation belt will not seriously affect film used in the LSUC experiment, I recommend that the film transport cassette (with Type NTB3 film) be exposed to a few Rad_{air} doses of tens of Mev protons. If the film is not affected by this exposure, the film transport cassette could be left in the present configuration. But if the film shows a serious effect, I suggest we consider transport of the film cassette in the Command Module where more adequate shielding is provided, or to strengthen the radiation shield at the film transport cassette with a 1/4 inch (1.7 g/cm^2) aluminum protective casing.

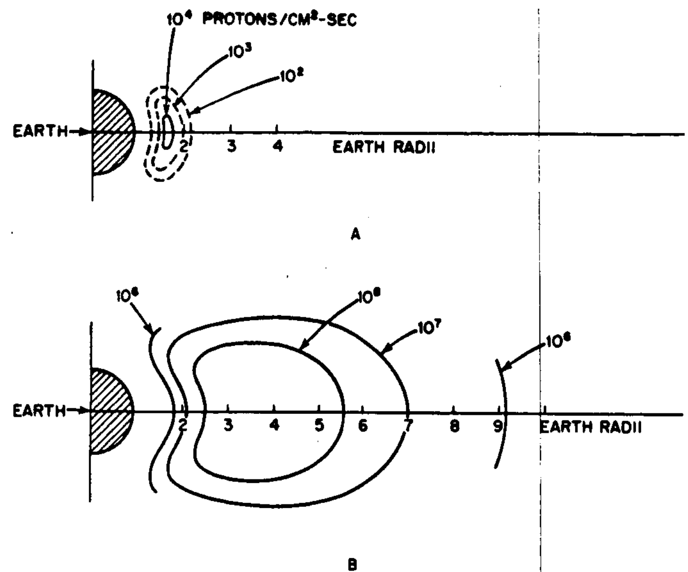
Acknowledgment

I thank A. P. Boysen, Jr. for bringing this problem to my attention, and I also thank N. P. Patterson for a stimulating discussion of the effect of radiation on the film.

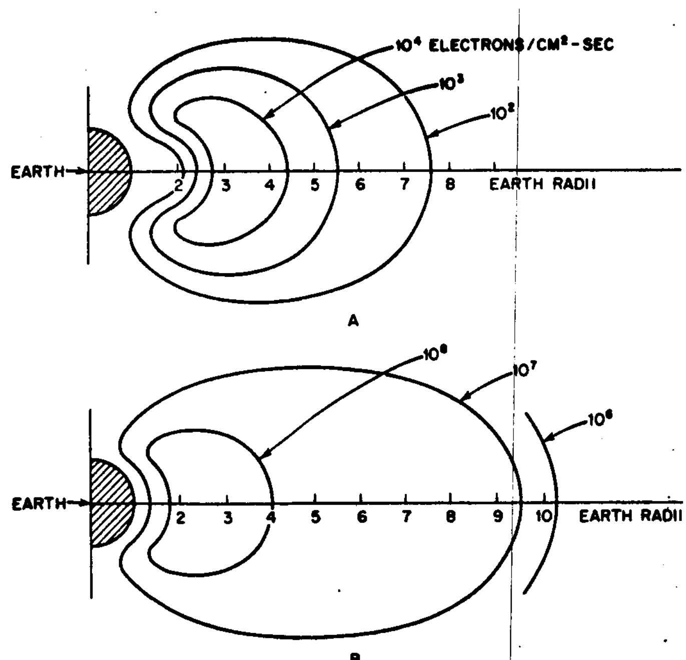
G. K. Chang

2015-GKC-ams G. K. Chang

Attachments



Idealized proton flux contours: (A) protons with energies greater than 30 million electron volts (a secondary maximum at 2.2 Earth radii is not shown); (B) protons with energies between 0.1 and 5 million electron volts (after J. A. Van Allen)



Idealized electron flux contours: (A) electrons with energies greater than 1.6 million electron volts; (B) electrons with energies greater than 40 kilo-electron volts to scale (after J. A. Van Allen)

(after Glasstone Sourcebook of the Space Sciences, pg. 555-557)

FIGURE 1 - RADIATION INTENSITY IN THE VAN ALLEN BELT

REFERENCES

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2. T. T. White, MSC (Private Communication).

3. "LM-6 Thermal Shield and Blanket Requirement", LAV-510-479, Grumman Aircraft Engineering Corporation, September 1968.

4. "The Effects of Changes in Skylab Film Response", Bellcomm Memorandum for File, N. P. Patterson, June 30, 1971.

5. C. W. Hill, Lockheed-Georgia (Private Communication).

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